



US Army Corps
of Engineers
Waterways Experiment
Station

Zebra Mussel Research

Technical Notes

Section 1 — Environmental Testing

Technical Note ZMR-1-32

October 1995

Tolerances of Zebra Mussels to Various Temperatures in the Mississippi and Ohio Rivers, 1988-1992

Background Zebra mussels (*Dreissena polymorpha*) have existed in the Mississippi and Ohio Rivers since 1981. Zebra mussels were introduced to these river systems via Lake Michigan and the Illinois River. By 1993 zebra mussels had spread down the Mississippi River to New Orleans, LA (Payne and Miller 1993). Based on the temperature tolerances of zebra mussels, predictions about mussel infestations in the Mississippi and Ohio Rivers can be made by examining water temperatures at various sites.

Purpose The purpose of this technical note is to summarize the temperatures of the Mississippi and Ohio Rivers at nine sites for water years 1988-92. In addition, the temperature tolerances of zebra mussels and their expected infestations in various regions of the Mississippi and Ohio Rivers are discussed.

Additional information This technical note was prepared by Mr. David C. Armistead, U.S. Army Engineer Waterways Experiment Station (WES). For additional information, contact Dr. Andrew C. Miller, (601) 634-2141, or Dr. Barry S. Payne, (601) 634-3837. Dr. Ed Theriot, WES, (601) 634-2678, is Manager of the Zebra Mussel Research Program.

Study area and methods Water temperature data for the Mississippi and Ohio Rivers were collected at nine sites between October 1988 and September 1992. Sites are located at or near cities distributed evenly along the main stems of the Mississippi and Ohio Rivers (Figure 1).

Temperature data for the Mississippi River at Vicksburg, MS, and for St. Louis, MO, McGregor, IA, and near Anoka, MN, were obtained from annual reports of the U.S. Geological Survey (1988a,b,c,d). Temperature data for the Mississippi River at New Orleans, LA, and Memphis, TN, were obtained from the U.S. Army Engineer Districts, New Orleans and Memphis, respectively. Temperature data for the Ohio River at Louisville, KY, and Belleville, WV, were obtained from the U.S. Geological Survey Districts, Louisville and Huntington, respectively. Temperature data for the Ohio River near Pittsburgh, PA, were obtained from Aquatic Systems Corporation (1988).

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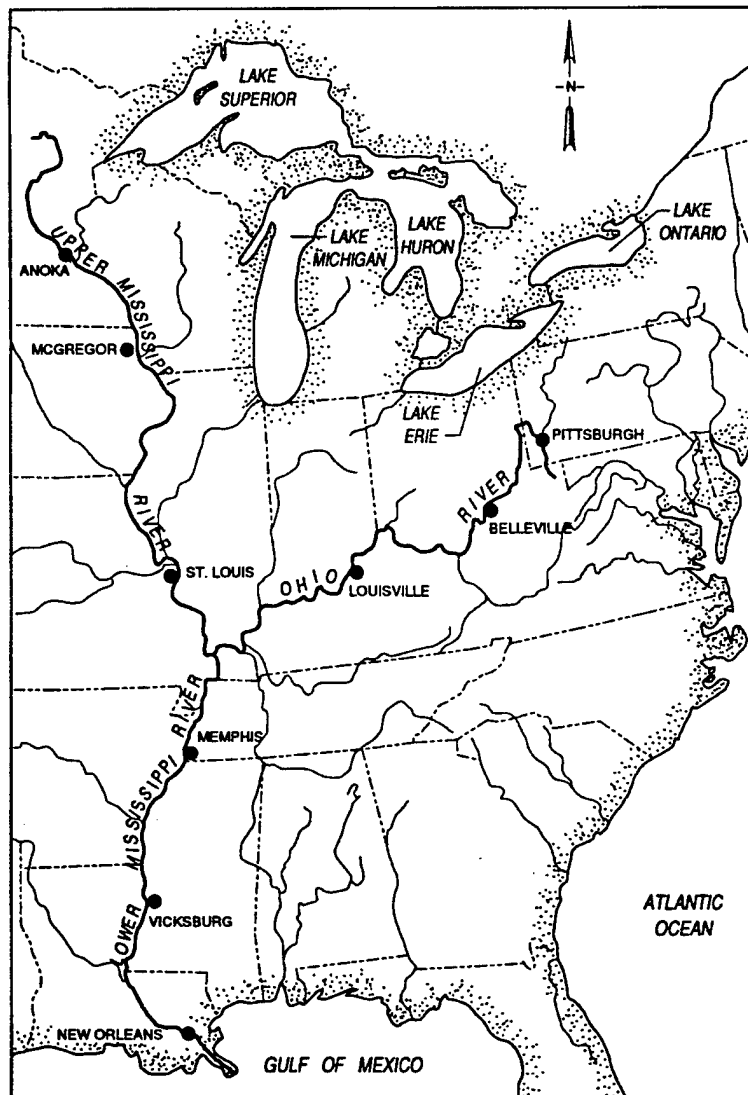


Figure 1. Study sites, Mississippi and Ohio Rivers

Data from each of the nine sites were summarized into monthly mean, maximum, and minimum temperatures. All calculations were done with Quattro Pro version 5.0 on a personal computer. The number of data points used to calculate the monthly statistics varied from 1 to 1,791 (Table 1). Temperature curves were constructed from the monthly statistics. Data for some months were unavailable.

Results Monthly mean temperatures of the Mississippi and Ohio Rivers varied depending on degrees of latitude (Figures 2-10). The northern latitudes had lower mean temperatures, and southern latitudes were warmer. The average mean temperature for July (typically, the hottest month of the year) for 1988-92 for the upper Mississippi River (UMR) near Anoka was 25.3 °C. The average mean temperature for July for 1988-92 for the upper Ohio River (UOR) near Pittsburgh was 25.6 °C. The average mean temperature for July for 1988-92 for the lower Mississippi River (LMR) at New Orleans was 28.4 °C. The monthly

Table 1. Number of Data Points Used in Mississippi and Ohio River for Monthly Temperature Calculations

Site ¹	Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
New Orleans, LA	1988	21	19	23	19	19	22	21	17	0	0	0	0
	1989	20	21	21	20	18	22	20	22	21	18	23	18
	1990	21	20	19	16	16	22	21	22	20	21	23	18
	1991	22	20	19	21	18	21	21	20	19	18	21	20
	1992	22	17	20	21	19	21	21	20	20	22	20	20
Vicksburg, MS	1988	24	18	31	31	29	31	30	31	20	16	8	0
	1989	19	28	20	29	28	31	26	31	30	31	31	30
	1990	29	26	7	30	28	31	30	11	18	31	31	30
	1991	30	30	31	31	28	31	30	31	30	31	31	30
	1992	20	30	31	31	29	31	30	31	30	31	31	30
Memphis, TN	1988	5	5	4	4	3	4	3	2	8	2	4	2
	1989	2	1	3	3	3	5	4	3	3	3	3	1
	1990	3	5	4	5	3	3	3	3	5	3	5	2
	1991	4	4	3	4	4	3	2	3	3	4	3	3
	1992	3	3	2	3	1	5	4	4	2	4	2	2
St. Louis, MO	1988	2	1	3	1	2	2	3	2	3	4	4	4
	1989	5	4	4	5	1	3	4	4	4	5	5	5
	1990	4	5	1	5	3	2	2	2	2	4	2	1
	1991	2	2	2	1	2	2	2	2	2	1	3	2
	1992	1	2	3	0	2	2	2	1	2	2	3	1
McGregor, IA	1988	9	8	8	8	9	9	8	9	8	9	9	10
	1989	8	9	10	2	6	11	9	8	8	9	9	8
	1990	9	10	9	9	8	9	8	9	10	13	9	7
	1991	10	8	9	8	9	8	10	9	8	10	8	8
	1992	9	9	9	9	8	9	9	9	10	9	9	13
Anoka, MN	1988	24	27	1	1	1	21	14	12	30	30	27	27
	1989	25	11	0	1	1	4	27	24	27	27	28	29
	1990	29	12	0	1	7	28	18	31	25	30	27	28
	1991	28	25	5	0	2	25	30	30	30	28	30	30
	1992	30	8	0	0	3	22	26	26	28	27	25	28
Louisville, KY	1988	0	0	0	646	695	717	655	739	710	713	743	682
	1989	661	719	743	560	671	743	682	634	706	743	738	719
	1990	725	713	654	714	671	743	711	729	719	743	603	432
	1991	201	23	1791	742	670	732	719	660	715	743	741	425
	1992	743	719	743	743	695	591	203	743	719	743	743	690
Belleville, WV	1988	0	0	0	0	0	0	0	0	0	0	0	104
	1989	392	713	737	737	665	737	683	737	713	737	737	713
	1990	737	658	737	737	665	737	713	735	713	737	737	713
	1991	737	713	737	737	594	737	691	731	681	737	693	781
	1992	402	293	737	737	689	737	714	737	624	737	737	713

¹ Number of data points not available for Pittsburgh, PA.

maximum temperatures for sites near Anoka and Pittsburgh never rose above 31 °C. However, the monthly maximum temperature at New Orleans reached 32, 33, and 36 °C in years 1988, 1990, and 1991, respectively.

The zebra mussel's threshold temperature for reproduction is 12 °C (Claudi and Mackie 1994). Depending on latitude, sites reached this threshold in early to late spring.

Discussion and conclusion

The upper incipient lethal temperature for zebra mussels is 31 °C with mean tolerated exposure times ranging from 52 to 292 hr, depending on acclimation temperature (McMahon and others 1995).

Temperatures at all sites in the more northern latitudes, including McGregor, IA, Anoka, MN, Belleville, WV, and Pittsburgh, PA, never exceeded the lethal temperature. Sites in the southern latitudes had a

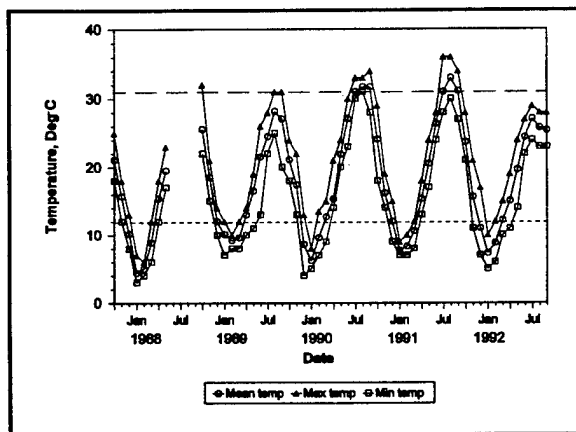


Figure 2. LMR temperature at New Orleans, LA, 1988-92

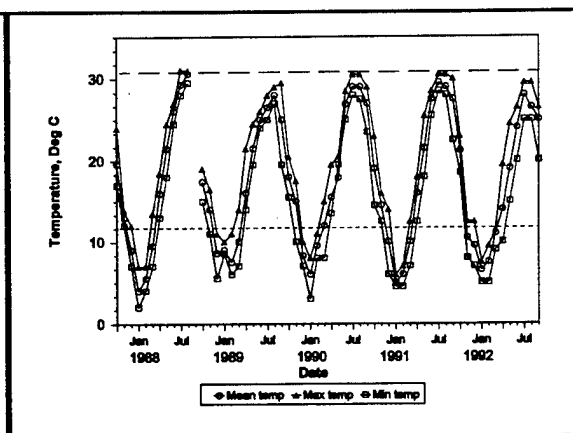


Figure 3. LMR temperature at Vicksburg, MS, 1988-92

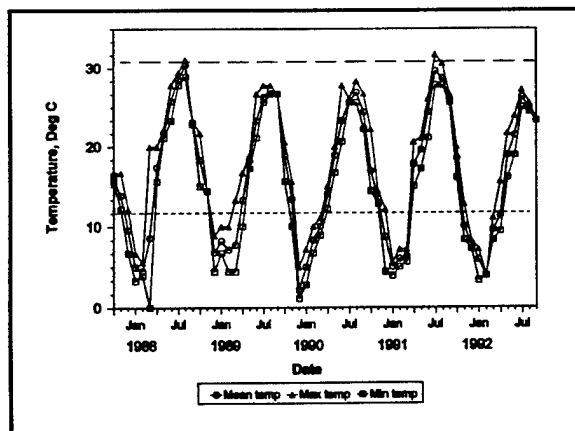


Figure 4. LMR temperature at Memphis, TN, 1988-92

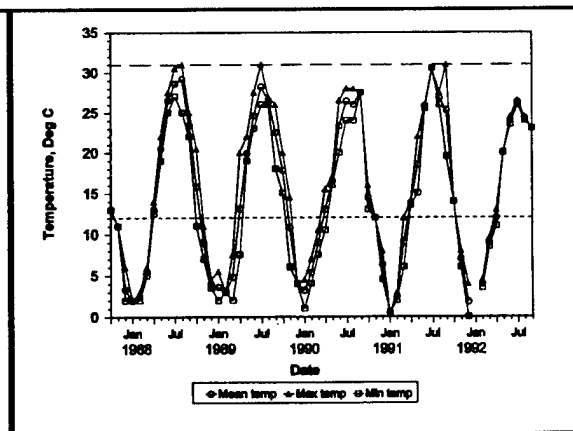


Figure 5. UMR temperature at St. Louis, MO, 1988-92

Note: In Figures 2-5, long dashed line (31 °C) indicates the upper incipient lethal temperature for mussels. Short dashed line (12 °C) indicates the threshold temperature for reproduction.

maximum temperature $>31^{\circ}\text{C}$ at some time during the 5-year period. These sites included New Orleans, LA, Vicksburg, MS, Memphis, TN, St. Louis, MO, and Louisville, KY. In some instances, the lethal temperature was exceeded for only a short duration, which probably resulted in little mortality. The mean temperature of the LMR at New Orleans remained above the lethal temperature for 3 months during 1990 and 1991. In these cases, conditions were basically unsuitable for zebra mussel survival.

All temperatures cited in this technical note were measured near the water surface. It is likely that the temperature in deeper parts of the river would be cooler and more suitable for zebra mussels. Regardless, these data illustrate that, during the summer of some years, there are periods of high temperature that could cause some zebra mussel stress and, possibly, mortality. These elevated

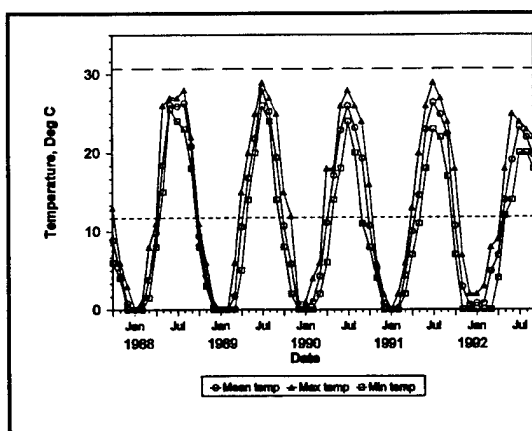


Figure 6. UMR temperature at McGregor, IA, 1988-92

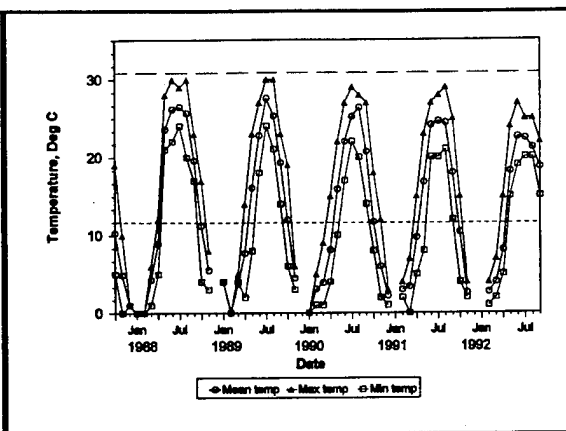


Figure 7. UMR temperature at Anoka, MN, 1988-92

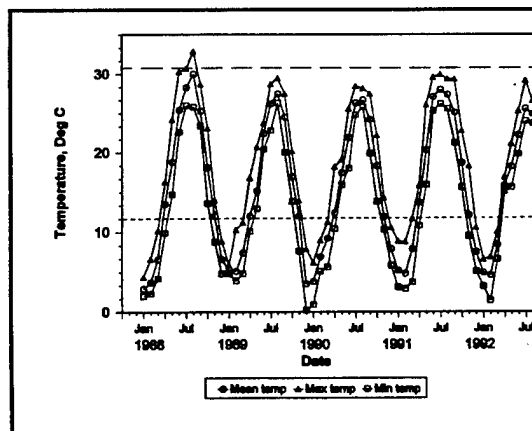


Figure 8. LOR temperature at Louisville, KY, 1988-92

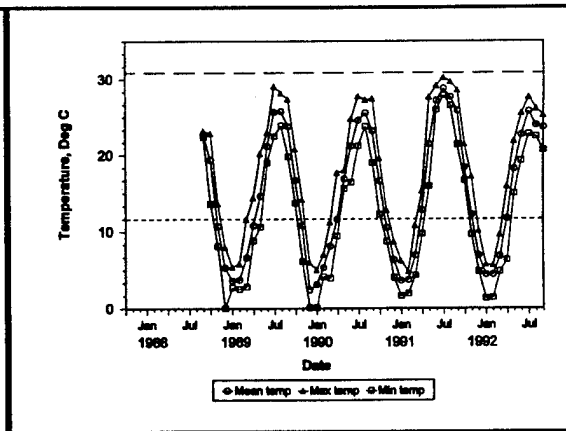


Figure 9. UOR temperature at Belleville, WV, 1988-92

Note: In Figures 6-9, long dashed line (31°C) indicates the upper incipient lethal temperature for mussels. Short dashed line (12°C) indicates the threshold temperature for reproduction.

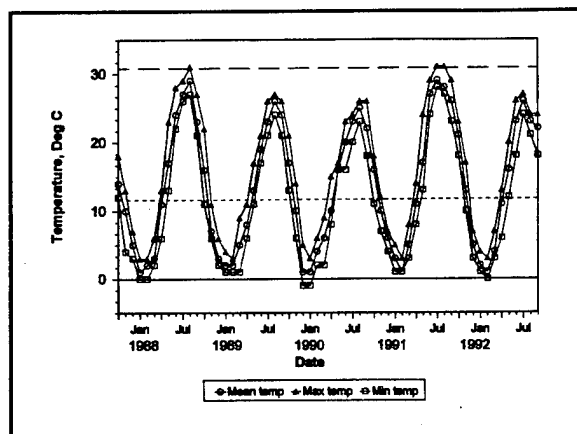


Figure 10. UOR temperatures near Pittsburgh, 1988-92. (Long dashed line (31 °C) indicates the upper incipient lethal temperature for mussels. Short dashed line (12 °C) indicates the threshold temperature for reproduction)

temperatures are not sufficiently high to cause mass mortalities. However, zebra mussels in the lower Mississippi and Ohio Rivers in the central and southern United States live in a potentially stressful environment, and ultimately, populations might not be as successful as those from northern latitudes.

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